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FLOOD PLAIN STUDY OF THE NORTH SASKATCHEWAN RIVER THROUGH EDMONTON

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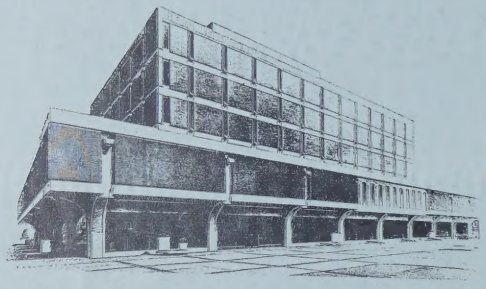

FLOOD PLAIN STUDY OF THE NORTH SASKATCHEWAN RIVER THROUGH EDMONTON

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Office of
the Deputy Minister

November 4, 1974

The Honourable W.J. Yurko, P. Eng.
Minister of The Environment
Government of Alberta
Legislative Building
EDMONTON, Alberta

Sir:

RE: FLOOD PLAIN STUDY OF THE NORTH SASKATCHEWAN RIVER THROUGH EDMONTON

The undersigned has the honour to transmit herewith a report on the flood risk to the low valley lands in Edmonton posed by the North Saskatchewan River.

A series of mosaics covering the valley clearly illustrate the areas subject to flooding while the body of the text, technical in nature, provides a discussion of data, assumptions and analyses used.

The report was prepared by the Technical Services Division as one of a series of such studies of the flood hazards faced by larger urban centres in Alberta.

Respectfully submitted,

E. E. Ballantyne

E.E. Ballantyne, D.V.M., P.Ag., F.R.S.H.
Deputy Minister

Alberta

ENVIRONMENT

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Office of
the Assistant Deputy Minister

November 4, 1974

E.E. Ballantyne, D.V.M., P. Ag., F.R.S.H.
Deputy Minister
Alberta Environment

Sir:

I take pleasure in submitting the report, "Flood Plain Study of the North Saskatchewan River through Edmonton", a description of the flooding potential of the North Saskatchewan River in the vicinity of the City.

The report, prepared by the River Engineering Branch of the Technical Services Division, delineates those areas throughout the valley bottom which would be covered with water in the event of floods of various frequencies. Such information has, in the past, been requested by the City authorities, Central Mortgage and Housing Corporation, and insurance companies, and is valuable in any engineering studies concerning the river or the flood plain.

The report includes a reference to the major historical floods, a description of the effect of the Bighorn and Brazeau Dams on the flood potential of the river and a discussion of several possible flood protective measures.

Respectfully submitted,

W. SOLODZUK, P. ENG.
Assistant Deputy Minister

Alberta

ENVIRONMENT

FLOOD PLAIN STUDY OF THE NORTH SASKATCHEWAN RIVER THROUGH EDMONTON

G. W. Samide and S. A. Lowe[1]

A flood plain study was conducted on the North Saskatchewan River through Edmonton. This was done by using an IBM 370/168 computer and a U.S. Hydrologic Engineering Center computer program to generate the water surface profiles. The profiles as computed were verified by existing water levels.

The purpose of the study was to determine the 1% (1 in 100 year return), 1.33% (1 in 75 year return), and 2% (1 in 50 year return) floods and to record the encroachment of these floods onto the flood plain throughout the developed areas. The extent of flooding of all low lying communities along the river was investigated and some protective measures were examined. The effect of the Brazeau Dam and Bighorn Dam on flood peaks through Edmonton and the main cause of floods in the North Saskatchewan River basin were also carefully considered. Flood delineation maps showing the extent of flooding in Edmonton are presented in a separate binder.

1 River Engineering Branch, Technical Services Division
Alberta Environment.

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SECTION 1

GENERAL

This report contains a flood-plain study of the North Saskatchewan River through Edmonton. This study considers the causes of floods, effects of upstream control plus some flood protection measures for some of the flood prone areas. The flood water levels were generated by the U.S Corps of Engineers HEC-2 Computer Program and verified by records of the 1915 floods.

1.1 Objective

The objectives of this study are:

(a) To delineate the flood plain for floods of the following return periods; 50, 75 and 100 years.

(b) To closely examine the flood frequency relationships for the low lying developments along the North Saskatchewan River within the city limits.

(c) To examine the low lying developments with respect to some types of flood protection.

1.2 Historical Review of Flooding in Edmonton

River stages through Edmonton have been measured by a staff gauge from 1911 and an automatic recorder from 1950 to the present date. Prior to the installation of the measuring gauge, two very large floods occurred in 1899 and 1900. During the recorded period since 1911, the two largest floods that occurred were in 1915 and 1952 respectively.

These two flood peaks over-topped the river banks and caused some flooding within the city limits.

1.3 1899 & 1900 Floods

These two flood peaks were approximated after 1911 when the staff gauge was installed in Edmonton. The 1899 flood peak occurred in August and reached a gauge height of 41.37[(1)] which is approximately 180,000 cfs. During the spring of 1899 the Low Level Bridge was under construction, and as a direct result of the flood, the piers were raised 8 feet to cope with dangerous floods[(2)].

1.4 1915 Flood

The 1915 flood peak was the largest flood to occur on the North Saskatchewan River at Edmonton since flow records have been taken at Edmonton or in living memory. The damage from this flood reached about $750,000 in Edmonton alone and approximately eight hundred families were left homeless[(2)]. Due to the long interval since the 1915 flood, most residents of Edmonton are unaware that the low lying areas can be flooded. The general policy of the City of Edmonton, however, is to restrict development of the river flood plain.

TABLE 1

NORTH SASKATCHEWAN RIVER AT EDMONTON - STATION NO. 05DF001

MAXIMUM ANNUAL DAILY DISCHARGES IN CFS

YEAR	MAXIMUM INSTANTANEOUS DISCHARGE	MAXIMUM MEAN DAILY DISCHARGE
1911	---	---
1912	---	74,100 CFS ON JUL 10
1913	---	32,600 CFS ON AUG 15
1914	---	61,700 CFS ON JUN 9
1915	205,000 CFS ON JUN 28	164,000 CFS ON JUN 29
1916	61,600 CFS ON JUN 22	58,800 CFS ON JUN 22
1917	---	65,600 CFS ON MAY 18
1918	---	35,300 CFS ON JUN 16
1919	---	19,900 CFS ON JUN 24
1920	---	57,200 CFS ON MAY 10
1921	27,400 CFS ON MAY 23	24,900 CFS ON MAY 23
1922	28,600 CFS AT 1900 MST ON AUG 18	25,800 CFS ON AUG 18
1923	99,600 CFS AT 0900 MST ON JUN 25	84,100 CFS ON JUN 25
1924	27,600 CFS AT ON JUL 5	27,500 CFS ON JUL 5
1925	77,000 CFS AT 1150 MST ON AUG 18	75,800 CFS ON AUG 18
1926	---	58,700 CFS ON SEPT 4
1927	45,300 CFS AT 1800 MST ON JUN 28	40,400 CFS ON JUN 29
1928	---	61,200 CFS ON JUL 27
1929	---	38,100 CFS ON JUN 5
1930	23,900 CFS AT 0600 MST ON JUN 13	23,700 CFS ON JUL 17
1931	---	39,200 CFS ON JUL 2
1932	---	66,000 CFS ON JUN 4
1933	---	34,400 CFS ON JUN 19
1934	---	28,100 CFS ON JUN 1
1935	---	46,300 CFS ON JUL 11
1936	---	40,400 CFS ON APR 19
1937	---	31,500 CFS ON JUL 17
1938	---	40,000 CFS ON JUL 4
1939	---	30,200 CFS ON JUN 28
1940	---	35,700 CFS ON APR 18
1941	---	26,700 CFS ON JUN 28
1942	---	42,300 CFS ON JUL 14
1943	---	44,000 CFS ON APR 12
1944	126,000 CFS AT 1600 MST ON JUN 16	122,000 CFS ON JUN 16
1945	---	24,300 CFS ON JUN 1
1946	---	44,700 CFS ON JUN 24
1947	---	28,600 CFS ON JUN 13
1948	---	65,400 CFS ON MAY 25
1949	---	32,700 CFS ON JUL 22

1950	53,700 CFS AT 0500 MST ON JUN 17	50,300 CFS ON JUN 17
1951	41,000 CFS AT 1300 MST ON MAY 3	39,000 CFS ON MAY 3
1952	132,000 CFS AT 1100 MST ON JUN 25	125,000 CFS ON JUN 25
1953	45,800 CFS AT 1000 MST ON JUN 5	44,900 CFS ON JUN 5
1954	118,000 CFS AT 2145 MST ON JUN 8	107,000 CFS ON JUN 8
1955	32,000 CFS AT 0100 MST ON JUN 15	30,000 CFS ON JUN 15
1956	26,600 CFS AT 1600 MST ON JUN 7	25,500 CFS ON JUN 7
1957	23,400 CFS AT 0700 MST ON MAY 22	21,800 CFS ON JUN 11
1958	52,100 CFS AT 1800 MST ON JUN 30	49,900 CFS ON JUL 1
1959	51,700 CFS AT 2200 MST ON JUN 28	46,100 CFS ON JUN 29
1960	38,800 CFS AT 1300 MST ON JUL 3	36,800 CFS ON JUL 3
1961	30,100 CFS AT 2100 MST ON JUL 31	27,200 CFS ON JUL 31
1962	28,500 CFS AT 0800 MST ON JUL 14	27,000 CFS ON AUG 6
1963	39,900 CFS AT 2359 MST ON JUL 17	37,100 CFS ON JUL 18
1964	49,700 CFS AT 0100 MST ON JUN 21	47,600 CFS ON JUN 21
1965	95,300 CFS AT 2000 MST ON JUN 29	91,600 CFS ON JUN 29
1966	61,800 CFS AT 1200 MST ON JUL 6	57,500 CFS ON JUL 6
1967	37,000 CFS AT 0900 MST ON JUN 19	35,300 CFS ON JUN 19
1968	23,300 CFS AT 0800 MST ON JUN 13	21,100 CFS ON AUG 9
1969	65,200 CFS AT 2149 MST ON JUL 7	61,300 CFS ON JUL 7
1970	57,000 CFS AT 1424 MST ON JUN 18	53,700 CFS ON JUN 18
1971	---	41,700 CFS ON JUN 11
1972	113,000 CFS AT 2000 MST ON JUN 27	105,000 CFS ON JUN 27
1973	25,400 CFS AT 0100 MST ON JUN 3	208,000 CFS ON JUN 26
1973	---	20,800 CFS ON JUN 26

MAXIMA OF DISCHARGE FOR THE PERIOD OF RECORD

MAXIMUM INSTANTANEOUS DISCHARGE IS 205,000 CFS ON JUNE 28, 1915
MAXIMUM DAILY DISCHARGE IS 164,000 CFS ON JUNE 29, 1915

NOTE: CFS MEANS CUBIC FEET PER SECOND

SECTION 2

HYDROLOGY

2.1 Introduction

It was assumed, for a statistical analysis, that flood peaks on the North Saskatchewan River are random and independent events. This is not entirely true for the flood peaks since 1963 when the Brazeau Dam was put into operation. However, for the purposes of analysis, the assumption is valid. The effects of the two dams are discussed in 3.3. The statistical distribution of flood peaks in the North Saskatchewan River through Edmonton have been a source of controversy for several years. In the past 108 years, the 1915 flood peak was the largest recorded in Edmonton.

2.2 Statistical Interpretation of Available Data

Table 1 provides a listing of all available flood peaks since 1911 which includes maximum mean daily discharges, maximum instantaneous discharges and where available, the hour that they were recorded. From this table, it is noted that the 1915 flood had a mean daily peak of 164,000 cfs and an approximate instantaneous peak of 205,000 cfs (at a gauge height of 45.0 feet). The second largest flood peak during this period on the North Saskatchewan River occurred in 1952. This flood peak reached a mean daily discharge of 125,000 cfs and an instantaneous peak of 132,000 cfs.

The lower line in Figure 1 shows the Log-Gumbel distribution for the maximum mean daily discharges at Edmonton based upon the data in Table 1. A straight line drawn through the plotted points fits extremely well. From this graph, the 1915 flood with a mean daily peak of 164,000 cfs

has a recurrence interval of 45 years. The estimated discharges of the 1899 & 1900 floods are data which can be useful to the foregoing statistical analysis. With these values added to Figure 1, a different plotting position for the 1915 flood is arrived at as indicated and the 1899 flood is plotted as second highest and 1900 is third highest. Even though these additional plotting points are not as close a fit in the graphical analysis, the original line derived from the data of Table 1 is assumed to be the most reliable and is taken as correct for the present study.

To obtain the instantaneous flood peaks which were used in the flood plain study, for various probabilities, the peaks were plotted above their maximum mean daily flows (top line Figure 1). The resulting line has a similar slope to the lower line in Figure 1. From the data of Table 1 we find that the maximum instantaneous peaks range from 5% to 15% greater than the maximum mean daily flood peaks.

At this time, the above analysis represents the best available interpretation of the annual maximum flood peaks on the North Saskatchewan River through Edmonton. Table 11 contains a summary of the probabilities and discharges used in the flood plain study.

TABLE II

Recurrence Interval (years)	Mean Daily Peak (cfs)	Instantaneous Peak (cfs)
1 in 50	170,000	190,000
1 in 75	203,000	227,000
1 in 100	230,000	260,000

2.3 Time of Flood

From Table 1 it is seen that the earliest recorded maximum annual flood peak occurred on April 12, 1943, while the latest date of the flood peak was September 4, 1926. On the average, during the recorded period, the day of the flood peak occurs around June 29th.

2.4 Bankfull Discharge

The report of "1915 Floods in Alberta"[1] by Water Survey of Canada states that the North Saskatchewan River "began to flood its banks at a gauge height of 35.0 feet at Edmonton and thus there was a depth of 10 feet of water at some points on the flats".

The Research Council of Alberta[3] has accumulated hydrologic and geomorphic data along the North Saskatchewan River through Edmonton. The data shows that the bankfull height through Edmonton is around 38.2 feet above mean bed level. Gauge height zero corresponds to the mean bed level at the recording station on the Low Level Bridge which is at elevation 1999.41 geodetic or 2042.41 city datum. This gauge zero is about 4 feet below the zero discharge elevation. Thus we can assume that the developed "flats" (i.e., Mayfair Park, Victoria Park, Rossdale, Walterdale, etc.) will begin to flood when the river stage reaches about 38.2 feet.

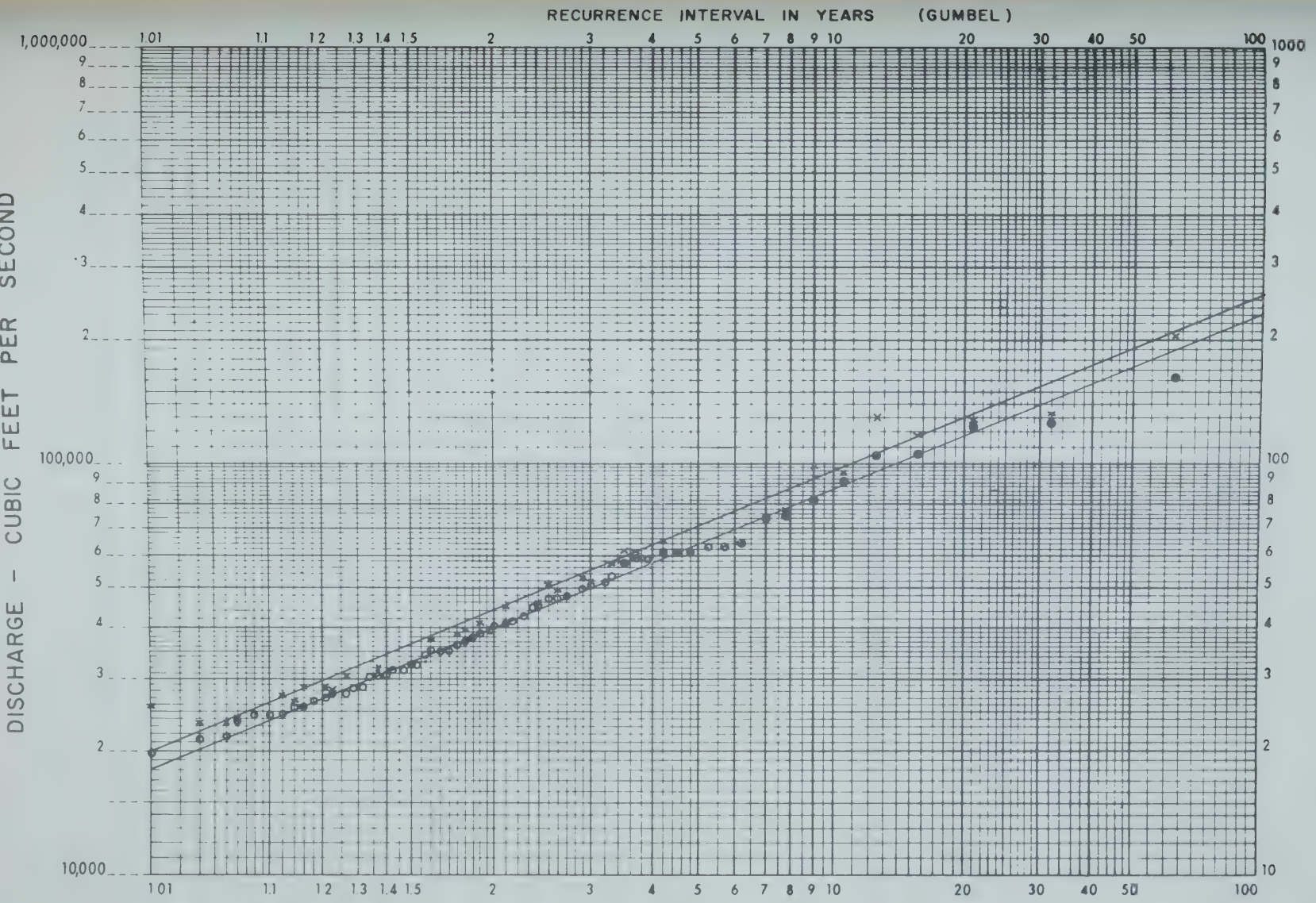

FIG. 1 - FREQUENCY CURVE OF ANNUAL MAXIMUM MEAN DAILY DISCHARGES
NORTH SASKATCHEWAN RIVER AT EDMONTON
(STATION Nº 5 DF-1 - DRAINAGE AREA 10,800 Sq. Mi.)

SECTION 3

EFFECT OF UPSTREAM CONTROL

3.1 General

The fact that two dams exist on tributaries of the North Saskatchewan River tends to influence flood peak probability. It has been estimated that the Brazeau Dam reduced the 1972 flood peak approximately 2 feet from natural conditions. It is the purpose of this section to examine the flood producing mechanism and examine the effect of storage on flood peaks at Edmonton.

3.2 Cause of Floods

Throughout the history of extreme floods on the North Saskatchewan River, it appears from Whyte[1] that the large floods are caused primarily by rainfall rather than snowmelt. The flood of 1899 (180,000 cfs at Edmonton or 17.1 cfs/sq.mi) was, in his opinion, caused by excessive rainfall while the snowmelt was a very minor concern. Primarily, with the 1915 flood (104,500 cfs maximum instantaneous discharge at Edmonton or 19.1 cfs/sq.mi), the heavy rainfall in the basin area created the flood. The snowmelt is considered by most to have created the saturated ground conditions which caused the large runoff coefficient. Thus, the probability of future floods should be determined by rainfall considerations, assuming saturated ground conditions. This period of saturated ground conditions extends from April to June. Thus, a large rainstorm during the spring and first part of the summer could be considered critical.

The 1972 flood through Edmonton had a peak of 116,000 cfs or 11 cfs/sq.mi. (maximum instantaneous) but the flood producing mechanism was very similar to that which produced very large floods in 1964 on the Waterton River (108 cfs/sq.mi) and Belly River (136 cfs/sq.mi)[4]. This mechanism was heavy rainstorms that moved into Alberta from the south or southeast direction, moved northwest along the foothills, and then quickly shifted towards the west. Upon reaching the frontal range of mountains, the weather fronts were forced upward causing extremely heavy rainfall. Thus, mountain streams do not pick up relatively large amounts of water until they move out into the foothills[5].

The prediction of such rainstorms becomes difficult as they may pass over large areas of prairie and drop no more than a token amount of rain; however, when they hit the frontal range of mountains, the resulting rainstorm may be disastrous.

3.3 Effect of Bighorn and Brazeau Dams

3.3 (a) Bighorn Dam

The Bighorn Dam has a storage capacity of 1,165,000 acre feet and a drainage basin area of 1430 square miles. The drainage basin is situated west of the frontal range of mountains with 60% of its catchment area above elevation 6,000 feet. Due to the large capacity of the reservoir, it was decided to restrict the spillway capacity to 50,000 cfs with each of the two turbines capable of passing 3,000 cfs.

In general, the Bighorn Dam should have only a small effect on flood peaks in Edmonton as most of the runoff above the dam is generated from snowmelt, not rainfall, However, since the Bighorn reservoir is

filling during the period when floods are occurring, the dam must have some effect on reducing peak flows on the North Saskatchewan River. Figure II shows the frequency distribution for flood peaks that would occur on the river at the damsite. The reservoir behind the Bighorn Dam is drawn to a very low level by the beginning of June so that there should be sufficient capacity to store most floods. Thus, during a flood, the maximum discharge released is about 5,000 cfs. The flood frequencies at the Bighorn dam site are as listed in Table III.

TABLE III

Frequency (return period)	Flow before dam (cfs)	Flow after dam (cfs)
1:50	21,700	5,000
1:75	21,200	5,000
1:100	20,800	5,000

Therefore, if a large storm were to occur over the Bighorn dam basin, a reduction in peak discharges of about 16,000 cfs could be expected due to the presence of the dam. The actual reduction in peak discharge is dependent on; (a) channel storage, (b) aerial distribution of rainfall, and (c) travel time of flood wave. All of these factors could influence the effects of the Bighorn dam on flood peaks. However, under idealized conditions, the maximum effect the dam could have on flood peaks through Edmonton would be a reduction of 16,000 cfs or a lowering of water levels in the order of 2 feet. This reduction in stage of 2 feet could only occur when flood peaks through Edmonton were in the range of a 1 in 50 year return period or greater.

3.3 (b) Brazeau Dam

The Brazeau Dam has a storage capacity of 450,000 acre-feet and a drainage basin of 2,138 square miles. The drainage basin is situated on a plain which extends slightly into the frontal range of mountain. Most of the catchment area of the Brazeau Dam lies below the 6,000 foot level. The dam at F.S.L. has an open spillway capable of passing a total of 60,000 cfs plus the capability of passing 26,000 cfs through two turbines and two venturies which gives a total discharge capacity of 86,000 cfs[5].

The Brazeau Dam could be expected to have a greater effect on flood peaks at Edmonton as its drainage basin is almost double the size of the Bighorn drainage basin and it is at a much lower elevation. Due to this relatively lower elevation of the catchment area, most of the runoff during a major flood would be caused by rainfall, not by snowmelt. The effect that the dam could have on flood peaks depends on; (a) elevation of reservoir at the beginning of the storm, (b) aerial distribution of the storm, (c) shape of the inflow hydrograph to the reservoir, and (d) dam outflow operations.

It has been shown in Section 2.3, Table II and Section 3.2, that large floods on the North Saskatchewan River are caused by large rainstorms which usually occur during the months of June or July. During June, the water level in the Brazeau Reservoir should be at or near elevation 3,163 feet[6]. Since the maximum reservoir level is at elevation 3,179 feet, there remains approximately 7 feet of live storage available for flood control from mid-June to August.

In order to assess the effect of the Brazeau Dam on flood peak reduction, the flood hydrograph of 1899 and 1915 were routed through the reservoir. These flood hydrographs were derived by Montreal Engineering[7] during design of the dam.

In performing the flood routing, the reservoir was assumed to be at elevation 3,163. For the first day of the flood, only 4,000 cfs was released through the powerhouse, thereafter spilling facilities were used to their maximum capacity.

When the 1899 flood was routed, it was found that peak flows were reduced from 112,000 cfs to 94,000 cfs or a reduction of 18,000 cfs. Also, it was noted that the peak outflow occurred one day later than the peak inflow. The results of routing the 1915 flood showed that the peak outflow was reduced to 85,000 cfs from 111,000 cfs or a reduction of 26,000 cfs. The results also indicated that the peak outflow lagged the peak inflow by a period of three days.

Thus, if floods similar to the 1899 and 1915 floods were to occur in the future, the reduction in peak discharge at the Brazeau damsite could be about 20,000 cfs. If we assume the same reduction in peak discharge at Edmonton, this would result in a reduction of water levels of approximately two and one half feet. However, this reduction in flood peaks is also dependent on the time of travel of the flood wave plus channel storage.

3.3 (c) Effect of Bighorn and Brazeau Dams

The main concern with these two dams is that they were built for power generation and winter flow augmentation; and their reservoirs are operated accordingly. The control of floods is not too paramount but an important concern is the careful release of large quantities of water. If the water is not released carefully, a flood situation could be created. The operation of the dams is related to spring runoff from the mountains, power requirements, and approaching weather fronts which could cause severe problems. The ideal situation is to end up in September with a full

reservoir. If too much water is released to make more storage available for an anticipated flood, the reservoir could be nearly empty in the fall. If the reservoirs are kept near full supply level too long and a heavy rainfall does occur, an excessive amount of water may have to be released into the river to avoid overtopping of the reservoir.

In considering the severe effect of a large rainstorm over the North Saskatchewan River basin, a hypothetical storm was considered. The storm would be large enough to cause at least a 1 in 50 year return flood and move from the north to the south along the foothills area. In this manner, large amounts of rain would fall first over the Brazeau River basin, followed by heavy rainfall over the southern part of the area on the Clearwater, Ram, and North Saskatchewan River basins. If no dams existed, the travel time of the flood peak of the North Saskatchewan River would arrive at the junction with the Brazeau River one day after the Brazeau River flood peak passed the junction. However, with the presence of the Brazeau dam, the flood peaks are lagged due to partial storage of the flood peak. With a one day lag on the Brazeau River flood peak, the peak from the North Saskatchewan River could easily reach the junction at the same time and the two peaks would coincide. The result of the two flood peaks coinciding could be little if any reduction in the flood peak at Edmonton. In fact, a situation could arise that, due to the coincidence of the flood peaks at the junction of the Brazeau River and North Saskatchewan River, the peak discharges at Edmonton may be greater than would normally occur without the coincident flood peaks.

Another possible situation would be a large rainstorm centered over the south eastern part of the North Saskatchewan, Clearwater, and Ram River basins where there are no river control works. The effect then

would be little if any reduction in flood peaks through Edmonton.

3.3 (d) Summary

In summation, the effect of the Bighorn and Brazeau Dams on the flood peaks at Edmonton is dependent on; (a) time and aerial distribution of the rainstorm, (b) the shape of the inflow hydrographs into the two reservoirs, (c) the timing of the flood wave, and (d) the outflow operations of both dams. Since all of these factors are indefinite, it is difficult to quantify the effects of the two dams. In using the flood routing techniques described previously, no consideration was given to time of the flood wave, channel storage, etc. The maximum effect the Bighorn Dam could have on flood peaks would be approximately a two and one half foot reduction in flood levels at Edmonton for a 1 in 50 year return flood or greater. Therefore, under ideal conditions, the maximum possible combined effect of the two dams would be a reduction of approximately four feet in river stage at Edmonton.

Since many of the factors affecting flood peak reduction are nebulous and difficult to quantify, however, the effect of the two dams was assumed to be negligible for the purpose of this report. Any effect that the Bighorn and Brazeau Dams do have should be considered as a small safety factor incorporated into the derived water surface elevations.

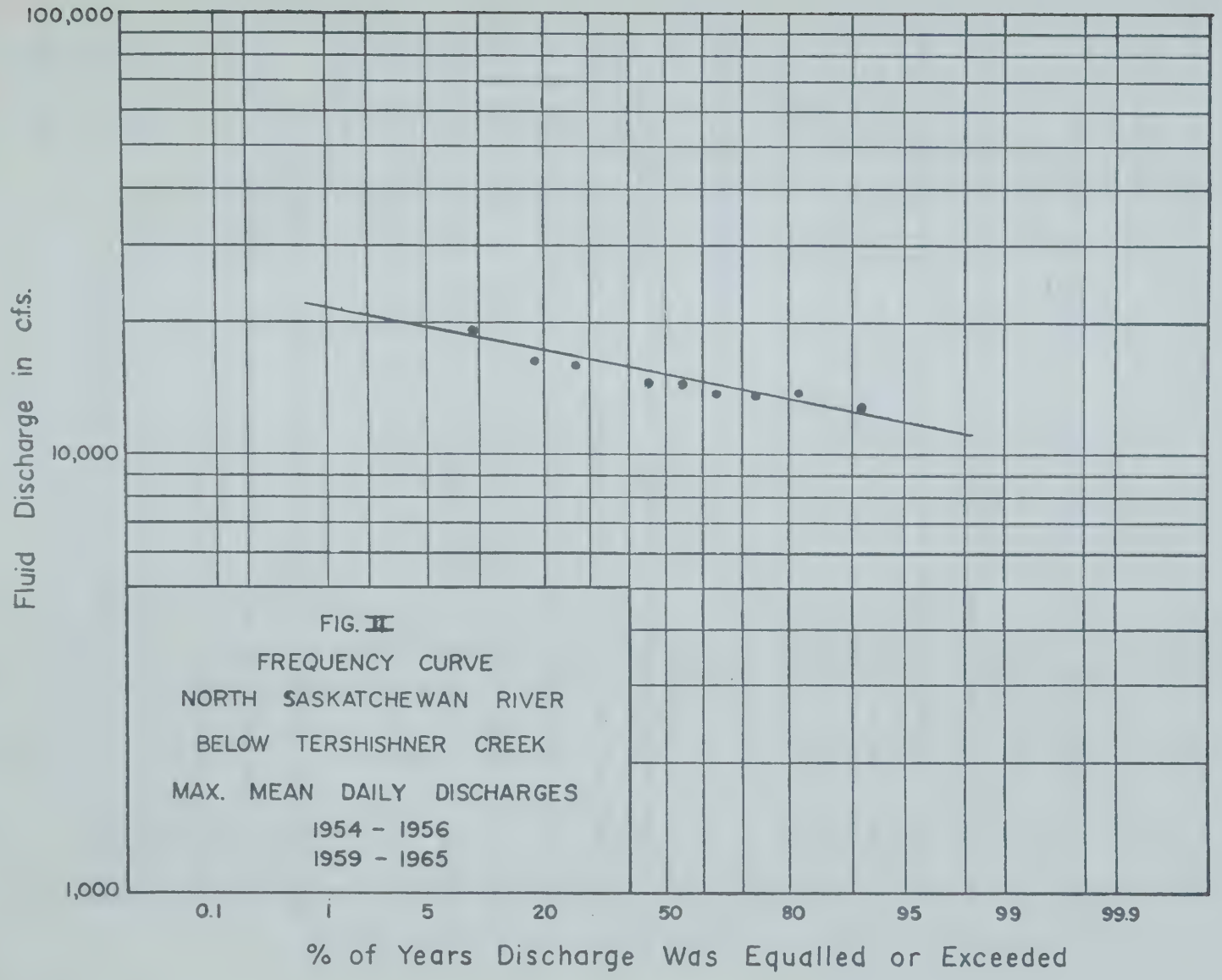

FIG. II

FREQUENCY CURVE

NORTH SASKATCHEWAN RIVER

BELOW TERSHISHNER CREEK

MAX. MEAN DAILY DISCHARGES

1954 - 1956

1959 - 1965

SECTION 4

FLOOD PLAIN STUDY

4.1 General

Tha major purpose of a flood plain study is to delineate the flood plain or establish the limit of an area which may be flooded by a flood of given magnitude. This is done so that planners and residents alike may observe where this concerns them with respect to possible flooding. A secondary aspect of the flood plain study was to consider flood protection measures that would protect property which may be subject to flooding.

4.2 Flood Protection

Flood protection is generally defined as protecting an area or urban center from flooding. This can be done by storing excessive flood waters in a reservoir. It may also be done by diverting the flood waters around an urban center or the area to be protected. It could mean the removal of damageable objects from the area which could be flooded, or it could mean the construction of dikes to keep the flood waters from the area to be protected.

In the case of the North Saskatchewan River through Edmonton, two of the major tributaries have dams on them; however these dams are too far away to be very effective in flood control. These dams have been discussed in detail in Section 3.3. The problem of diverting the flood waters is not an economical feasibility in Edmonton as it is about 160 feet from the river bed to the top of the surrounding prairie.

The last two methods, i.e., removal of damageable objects and dike construction, may be possible but very expensive if applied to the City of Edmonton.

4.2 (a) Relocation

This method of flood protection involves moving all the homes, businesses and public utilities that could be damaged by flood waters to a location where they would not be damaged. If land is available for relocation, this aspect of flood protection would still be very expensive. Within the City of Edmonton this type of protection would be extremely expensive due to the high cost of land and high cost of relocation for all the areas concerned.

4.2 (b) Diking

This alternative is not particularly desirable from any viewpoint. The main problem with dikes is that, if they are over-topped, the damage occurring would be as large or larger than if the dikes did not exist. It has been found from sad experience that far too many people have placed their complete faith in dykes only to have them fail or be over-topped[8]. Therefore, they are considered in this report only as an unreliable alternate solution.

The dike designs are based upon contour maps with 10 foot contour intervals (or 2 foot contour intervals for some of the low lying areas). Thus, the elevation of the dikes suggested in this report have a freeboard sufficient to contain the possible error in contours, the uncertainty of

water surface profiles plus a very small allowance for an ice or log jam on the Low Level Bridge. In every case suggested dike elevations are sufficient to protect against floods up to and including the 1 in 100 year occurrence only.

4.3 Flood-Proofing

Another possible method of flood protection would be the flood-proofing of buildings. This would allow the lower floor of a building to be flooded. The damage of the building and its' contents while flooded would be reduced to a minimum by proper structural design. The upper edges of a flood plain could be a suitable location for some developments since the flood-proofing of buildings could be accomplished at a moderate cost. The encroachment on the flooding would be negligible and the threat to life would be minimized. "Flood-proofing shows special promise in a situation where moderate flooding with low-stage, low velocity and short duration is experienced; where traditional type flood protection is neither feasible or affords only marginal protection."[9] Due to the techniques involved, it would be more economical to flood-proof a new rather than existing building. While flood-proofing usually implies keeping the water out of a building, intentional flooding could easily be a very important aspect of this technique.

If water is to be kept out of a building, the structural design must allow for water loads against the walls, plus a possible flotation of the whole building. The electrical wiring would not have to be specially located but there would be only a limited amount of doors and windows on the lower floors or floor. The openings that do exist must be able to be sealed against intruding flood waters. The degree of water-proofing used

would be directly related to the contents of the floors of the building that could be flooded. Usually, the water-proofing materials used in a building extend upwards only slightly past the expected flood elevation. To deal with expected seepage, sump pumps would be installed in special wells within the building.

The more economical means of dealing with floods would be the intentional flooding of the lower level of the building. This would decrease the structural requirements to withstand hydrostatic loads plus the expensive sealant materials normally required for water-proofing a building. The buildings would then intentionally be flooded with clean water so that a slight flow from the inside of the building to the outside of the building would exist. This would serve to keep heavy silt laden water out of the structure and minimize some damage. Relief valves would also be installed to prevent an excessive build-up of water inside the building which could cause excessive damage if the flood peak decreased suddenly. All electrical panels must be located above the flood peak elevation and provision made for the shut down of all mechanical equipment in the building.

Thus, it would be quite possible to utilize some position of the flood plain but due allowance must be made for flooding of the structure. However, it would be in the best interest for the minimization of damage, to restrict flood plain areas for parks and recreational parks.

4.4 Flood Plain Areas

It is recognized from the 1915 flood that several sections of the low-lying areas would be subject to flooding and the main purpose of this report was to study those areas in particular. From Section 2.2 and

Table II we see that the equivalent of the 1915 flood is not the most serious flood to be expected. The developed areas which would be affected by a 1 in 100 year flood were as follows: Riverdale, Cloverdale, Rossdale, Lavigne, Walterdale Park, and Buena Vista. Each area is dealt with separately as to flooding potential and is delineated on mosaics in a separate binder.

4.4 (a) Riverdale

The community of Riverdale is shown on Plate 8 of the mosaics. A 1 in 50 year flood (2% probability) would cover about 80% of the community; a 1 in 100 year flood (1% probability) would cover about 90% of the area. The area would begin to flood at a discharge of about 110,000 cfs which corresponds to a 1 in 11 year return probability. During the 1972 flood, water almost reached bankfull stage, however, none of the houses were flooded. From this, it is apparent that this area is easily subject to flooding. The 1 in 100 year flood level would reach an approximate elevation of 2091.0 (city datum).

In considering dikes for this area it was seen that the base elevation would be about 2073.0 (city datum) to protect the area against a 1 in 100 year flood, the dikes would be about 23 feet high and 5400 feet long. For a preliminary design side slope of 4:1, the volume of earth required for the dikes would be about 540,000 cubic yards. The cost of this dike in place would be in the neighbourhood of 1.1 million dollars.

4.4 (b) Cloverdale

The community of Cloverdale is shown on top of Plate 9. This area would begin to flood at about 125,000 cfs which would correspond to a

probability of flooding of 6.7% (1 in 15 year return) flood. Approximately 50% of the area would be flooded by a 1% (1 in 50 year return) flood while about 80% would be flooded by a 1% (100 year return) flood. The area that would be flooded is parallel to the river at this location and about one full block back from the river. Mill Creek which enters the North Saskatchewan River west of the district would back water up to about 3500 feet upstream from the river. Although this area is small, protection by dikes would be very expensive.

The 1 in 100 year flood level would be at elevation 2076.0 (city datum) and the dike would have a height of about 22 feet. The dikes would extend from Strathern Hill on the east to the James MacDonald bridge on the west side of the community. However, they could be shortened considerably on the west by swinging south and tying into Connors Road. This shortened dike would be about 350,000 cubic yards at a cost of approximately $700,000.

4.4 (c) Low Level Bridge

This bridge (Plate 9) requires special consideration as it is the lowest bridge in Edmonton. A photograph taken during the 1915 flood[2] shows the water piled up in the center of the river against the low chord of the bridge. A specially loaded train was placed on the bridge to assist in holding it in place. This photograph shows the water flowing freely under the low chord of the bridge only at the end sections. Since the flood, the entire bridge has been raised 3.0 feet (in 1948) to prevent the bridge from obstructing the flow of high water.

The 1 in 100 year water level just upstream of the Low Level Bridge

would be at elevation 2091.2 (city datum) while the low chord of the bridge was found to be elevation 2090.0 by a 1973 survey. Any debris in the river would catch on the low chord and remain there until the water level dropped. The 1 in 75 year water level at the Low Level Bridge would reach elevation 2089.0 and the 1 in 50 year water level would reach elevation 2087.0.

The backwater effect due to the 1% flood is about 1.1 feet immediately upstream from the bridge. This effect does not take into account any floating debris that may be trapped by the low chord of the bridge. If debris is trapped, the water level upstream will rise suddenly as the open area beneath the bridge is reduced. The extent of the rise in water levels depends on the amount of floating debris trapped by the bridge. A smaller backwater effect is expected during the 1 in 75 year return flow. Average velocities in the river during these two flood peaks is expected to be in the order of 10 to 12 feet per second. Due to the short duration of the flood peak, some scour of the river bed is expected at the bridge site. However, it would not be severe enough to cause collapse of the bridge.

4.4 (d) Rossdale

From Plates 9 and 10 it is seen that 70% of the residential section will be flooded during the 1 in 100 year flood, however, the water treatment plant and the Rossdale Power Generation Station would not be flooded. The community would begin to flood at about 125,000 cfs which is a 1 in 15 year return flood (6.7% probability). During the 1972 flood, water was standing in the streets parallel to the river to a depth of several inches, however, none of the homes in the area were flooded.

The flood return periods and their corresponding approximate city datum elevations at the Power Plant location are; 1 in 50 year return flood (elevation 2090.0); 1 in 75 year return flood (elevation 2092.0); and 1 in 100 year return flood (elevation 2095.0). It should be remembered that these values are subject to change both from varying channel roughness and from backwater effects from the Low Level Bridge. To combat such fluctuations, it would be very wise when considering potential flooding, to add about 3 to 4 feet to the above elevations and then seriously consider 2 feet of freeboard. Thus, the 1 in 100 year flood level could easily rise to 2102.0 from 2095 with no warning whatever due to backwater effects. For this reason alone dikes are a risky business as they can be over-topped so easily if a log jam or ice jam should occur downstream from the concerned area.

To protect this area the base of the dikes would be at elevation 2078.0 (city datum) with a dike height of about 23 feet. The length would be in the order of 5000 feet. The volume of earth required to complete this dike would be 500,000 cubic yards at a cost of 1 million dollars.

4.4 (e) Walterdale Park

The only concern in this area is the Kinsmen Field House (Plate 10) and the proposed swimming pool nearby. The contour maps available indicate that the elevation of the area surrounding the Field House location is approximately 2090.0. It appears that the Field House would be safe from a 1 in 50 year return flood. To protect it from the 1 in 75 year and 1 in 100 year return floods, minor diking would be required. The 1915 photographs show the entire lower park area flooded, but do not show what happened in the Field House location. The elevations of the flood

levels are the same as given for the Rossdale Generating Station with the same cautions as to the application of these levels and the possibility of sudden backwater effects that may be created.

This area begins to flood at about 150,000 cfs which corresponds to a 1 in 24 year return flood. Thus, it is somewhat higher than most of Rossdale and slightly more secure against flooding.

4.4 (f) Victoria Park

In this area (Plate 10 & 11) only the east section would be flooded during a 1 in 50 year flood. However, the whole park area and golf course would be under water during the 1 in 75 year and 1 in 100 year return floods. The clubhouse for the golf course would be safe from floods, however, the Royal Glenora Club may be flooded slightly even during the 1 in 50 year flood. The contours in the area of the Royal Glenora are approximate and subject to a ±5 foot contour error.

Caution should be exercised in this area as flooding is a distinct possibility depending on elevations. The 1 in 100 year flood could reach an elevation of 2102.0 (city datum) with some backwater effects from the Low Level Bridge. The remainder of Victoria Park would suffer little damage from any flood and is of no serious concern.

4.4 (g) Mayfair Park

As seen from Plate 11, only the lower areas of the park and golf course would be affected by flooding. The contours around the lake on Plate 9 are approximate and subject to a 5 foot error (plus or minus) due to the contour interval. A few shelters may be damaged slightly but not enough to warrant the consideration of dikes for this area.

4.4 (h) Buena Vista

This district is seen on Plates 12 and 13. It appears from the mosaic that the area is relatively free from flooding from the 1 in 50 year return and 1 in 75 return floods. However, the 1 in 100 year return flood may come close to causing some damage. The main concern here is in the prevention of damage. This may be done easily by restricting further development of the district in the flood prone areas as set out on the mosaic. It would also appear that the Storyland Valley Zoo is safe from possible flooding.

4.4 (i) Whitemud Creek Park

The park area shown on Plate 13 will undoubtedly be flooded during all flood frequencies considered in this report. The flooding would extend up Whitemud Creek some distance due to its flat gradient. There are some buildings shown on the mosaic just southeast of the Quesnell Bridge that are very flood prone.

4.4 (j) Fort Edmonton Park

The location of the reconstructed Fort Edmonton is shown on Plate 13. The location lies within the flood plain area. The park in general begins to flood at about 130,000 cfs which corresponds to a flood frequency of 1 in 16 years or 6.25% probability. It is hoped that the timber walls of Fort Edmonton are strong enough to withstand the force of the water during high floods.

4.4 (k) Edmonton Country Club

This area on Plates 14 and 15 is subject to flooding on the lower areas only. It would appear that the clubhouse is quite safe from all floods.

4.4 (l) Terwilliger Park

This is a park (Plate 15) that has been newly created by the City of Edmonton. From the flood plain boundaries it is seen that most of the park area can be flooded by the 1 in 50 year return flood. In examining the area closely, it begins to flood at a discharge of about 100,000 cfs which corresponds to a flood frequency of 1 in 8.5 year return period or 11.8% probability of flooding. It is obvious that the lower portions are easily subject to flooding, however, the contour interval error of 5.0 feet must be considered. Thus, this mosaic could be very useful in locating permanent buildings or roads in the area for future use.

4.4 (m) Big Island

Since considerable landscaping and possible land filling will be done in this area, it was considered advisable to wait until the proposed work was outlined before the flooding potential could be considered.

SECTION 5

COMPUTER PROGRAM SIMULATION

5.1 General

Due to the trial and error procedure necessary for good accuracy, it was decided to use a computer program to carry out the necessary computations. The data was obtained from a combination of hydrophonic sounding of the river bed, land surveying for the section from the water level to the edge of the banks, and a contour plan arrived at from aerial photography. The results of the program were placed on a contour map and then transferred to an air photo mosaic of the City of Edmonton. It was thought that the flood plain boundaries on a mosaic would have far more meaning than the boundaries on a contour plan.

5.2 Computer Programs Available

The computer program used was created by the U.S. Army Corps of Engineers in the Hydrologic Engineering Center in California. It was written specifically to determine water surface profiles in a river or channel and is commonly called HEC-2. This computer program applies Bernoulli's Theorem for total energy available at each cross-section. Between the cross-sections, the friction head loss is determined by use of Manning's equation. The average friction slope between any two cross-sections is determined by the average of the conveyance term of both cross-sections. The general procedure for calculation is a step by step trial and error method. This program has many options available for detailed analysis and simulation of future conditions. It has an option of a variable roughness coefficient across the flood plain in addition

to a vertical variation of Manning's "n" within the channel which may easily be inserted at any point in the program.

5.3 Program Assumptions

To apply the computer program to this study, many assumptions had to be made. When the cross-sections were surveyed initially, the flood plain was not taken into account. Thus, the cross-sections are perpendicular to the direction of flow, but when they emerge onto the flood plain some alterations were made in sections where a wide flood plain existed, primarily on the inside of a large bend in the river. Since the program considers the distance between cross-sections on the right bank, left bank and center of channel, very little error was introduced to the main portion of the river flow.

The second main assumption was the value for Manning's "n" for the flood plain. Since most areas in the flood plain consist of trees, gravel pits and grassy fields, there was little difficulty in selecting suitable values with the assistance of Manning's roughness tables[10]. A value of 0.999 was selected for building as this, in effect, creates a barrier to all flow.

To apply the computed results with confidence, they must agree to some extent with previous recorded high water marks. The 1972 flood with an instantaneous peak of 116,000 cfs was used as a first check and the computed results were found to be within 1 foot of the surveyed high water marks. However, this one check was insufficient for accurate results. During the 1915 flood, a maximum gauge height of 45.04 was recorded[1] which is elevation 2087.45 (city datum). Using a Manning's "n" of 0.0306,

an elevation of 2087.02 was computed at the gauging station, 0.43 feet below the recorded values.

Using the value of 0.0306 for "n", a channel rating curve was established for the larger flows and the water surface profiles were started using these values. Since the profiles were commenced 8.5 miles downstream from Edmonton, by the time the calculated water surface profiles reached the city, the profile was stable and any errors introduced at the start had been cancelled out.

The last major assumption was in the values of bridge losses and expansion and contraction coefficients. Those used were recommended by the Corps of Engineers in the HEC-2 users' manual.

The sounding of the North Saskatchewan River bed and surveying of the river banks were carried out in 1972[11] and extended by means of contour maps previously discussed. The survey details the eleven bridges through the City of Edmonton and were supplied by the City of Edmonton, Planning Branch and the Alberta Department of Highways and Transport, Bridge Branch.

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